INTENSIONAL EPISTEMIC WHOLES
A STUDY IN THE ONTOLOGY OF COLLECTIVITY

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1 Groups and kinds of wholes

In formal ontology[1], for both concrete and abstract objects, the principle of compositionality amounts to the statement that the constitution and the representation of the whole is a function of the constitution and the representation of the parts and the way they are assembled. In this paper we analyze the notion of *group* that we formally treat as an abstract whole whose parts are its members. Our investigation is based on natural language data and in particular plural (*the boys*) and conjoined noun phrases (*John and Mary*, *the boy and the girl*, *the boys and the girls*) in relation with distributive or singular predication (i.e. predicates which only denote singular atoms such as *walk*, *be nice*, *be in some place...*).

The notion of group[2] has been extensively examined in the literature on plurality in recent years. Major advances in this domain have shown that formal ontology provides powerful means for understanding this notion[3]. On the other hand, natural language data can lead us to revise the existing models for part-whole structures and to elaborate new ones.

From the theoretical point of view, our aim is to question the principle of compositionality in two respects. First, with respect to the parts, one

[1]Following the doctrine (Husserl, 1901), by "formal ontology", we refer to the study of formal structures amongst objects and their parts.

[2]This notion is meant by various labels. The most popular are *collection*, *set*, *whole*, $integrated-whole$, *group atom*. However, they profoundly differ in the way they capture it. The first two roughly refer to groups as to sets without unity; the others emphasize their monadic character. However, as we show in this paper, only a close inspection of the theories into which they are defined can make justice of these differences.

[3]See in particular the works of (Lasersohn, 1995), (Moltmann, 1997), (Schwarzschild, 1996) and (Landman, 2000) explicitly applying formal ontology techniques to the analysis of plurality.

has to state clearly under what conditions two ontologically individuated objects can be composed into a whole.[4] Secondly, with respect to the whole, one has to predict the nature of the object resulting from the composition of some particular parts and a specific mode of assembling.

On the phenomenological side, we analyze a kind of collective interpretation that we label as "collectivity as dependence" and from now on CODEP. This case poses a real challenge to existing theories of mereology and ultimately to compositionality in the domain of abstract objects. Our claim is that none of the foundational models for part-whole relations is able to explain this phenomenon, and a new conception of whole has to be worked out.

Let us introduce the phenomenon of CODEP by two examples. First of all, to capture this notion, one has to distinguish it from that of "juxtaposition". Consider the propositional content of the following sentence.

(1) John and Mary are walking along the beach

The scene described in (1) is such that there are two people waking side by side along the same trajectory. This scene can be interpreted in two ways:

(i) *juxtaposition or genuine distributive interpretation* - two people are *accidentally* walking side by side, or

(ii) *CODEP* - two people are walking together (as a group) along the same trajectory.

The first interpretation appeals to a minimal amount of composition, which only consists in acknowledging that two people satisfy the same description. The second interpretation appeals to a real process of composition which leads to see two people as forming a whole, or a group.

Secondly, to understand CODEP, one has to distinguish it form the notion of "collective responsibility". Consider (2).

(2) The boys sing

This sentence is comparable to (1) in that the predication is singular. Three interpretations are immediately available:

(i) *juxtaposition or genuine distributive interpretation*: each of the boys sings, but they are not coordinating their singings (= (1i))[5];

[4] The parts of a whole are not always seen as ontologically independent, especially with respect to organisms and concrete objects, as Aristotle states in the *De Anima*, II-1,2. In the case of group members, they certainly are.

[5] We discard here cases of distributions to collections in which subcollections of the set

(ii) *collectivity as dependence interpretation*: each of the boys necessarily sings, and they are all coordinating their singings with one another (= (1ii));

(iii) *collective responsibility interpretation*: all of them are not necessarily singing, but there is a collective responsibility, insofar as they are intended to form a chorus.

The major difference between (ii) and (iii) is that under (iii) the boys are expected to form an entity "chorus", while in (ii) it is by virtue of coordinating their singings that they are conceived as a group. This group does not necessarily have an independent status from the actual coordination of singings. This points to the fact that the second interpretation is somehow in between the two others: it requires that each of the boys sings (= (i) and $\neq$(iii)), and that they do coordinate their singings (= (iii) but $\neq$(i)).

It is clear, then, that a proper mereological theory will have to predict, first, under what conditions, *ceteris paribus*, CODEP interpretation is enhanced only in some but not all cases: provided that the scene under the distributive and CODEP interpretations is exactly the same, one has to explain by virtue of what interpretative process the second interpretation raises (difference between interpretation (i) and (ii) of (1) and (2)). Secondly, the model will have to make explicit the nature of the whole that results from this composition (difference between (ii) and (iii) of (2))[6].

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denoted by the plural NP are individuated as the proper *loci* for the application of the property. In this case, for instance, the boys would be separated into two - or more - subcollections and the property *sing* would be predicated of these subgroups. Once the proper level of individuability has been chosen, the property is distributed in the same way as in cases of distribution to genuine individuals. This procedure requires that a huge amount of information be "upgraded" contextually but seems to be explainable on an extensional basis (Gillon, 1987; Schwarzschild, 1997) in the same way as distributivity to non-group atoms. This phenomenon is to be correctly predicted by any model of plurality. This would require a long and overly detailed explanation and is outside the scope of this paper.

[6]The "collective responsibility" interpretation seems difficult for (1), unless one admits that in the case where one person brings the other one on her shoulders they can be nonetheless said to be walking "as a group". This seems an unacceptable interpretation for most of the speakers. Another case seems more triggering, that in which one of the people is handicapped and moves on a wheel chair pushed by other person. One could nevertheless respond that the wheel chair provides a way of moving and that this is not a collective responsibility, but a CODEP interpretation according to which the two people have to adjust their movements to one another and no entity "group" pre-exists the mere event of walking. It is then not unanimously recognized that "collective responsibility" is a possible interpretation for the predicate *walk* and because its availability would eventually be added to CODEP interpretation, without replacing it, we prefer not to commit ourselves.

There exist different conceptions of part-whole relations in the light of which these data have been explained. In a very recent study, Meirav (2003) has shown that they can be reduced to two foundational ways of representing wholes, either as sums or as unities and that, when they are conceived as unities, one can either explain their monadicity by the dependence relations linking the parts[7], or to consider them as ontological primitives[8].

In the first part of this paper, in section (2), we show that none of these conceptions of wholes can explain the notion of CODEP. On the phenomenological side, we show that two features characterize this case: first, with respect to the parts, one can easily state that they are linked by coherence - or dependence - relations. When walking "together", if one of the people turns, the other will turn too, if one stops, the other will stop too, and so on. Secondly, with respect to the nature of the whole, one can equally easily state that this is neither the sum of its parts, nor a unity existing above them: it does not exist a common walk out of the two distinct walks of the two people. On the theoretical side, we consider in turn models of wholes as sums and wholes as unity and analyze some formal implementations. We argue that theories of wholes as sums cannot capture the first feature, and that theories of wholes as unities would compel us to accept the existence of a whole above the parts not fitting the case of CODEP. Our conclusion is that another notion of whole is needed, one that we will call *wholes as networks*.

In the second part of the paper, in section (3), we first present the notion of whole as network informally, and then elaborate a formal account. The definition of wholes as networks is designed to grasp the fact that, under CODEP reading, the parts are seen as related via their properties, and that this relation takes the form of an inferential constraint. From a theoretical point of view, this corresponds to a counterfactual reasoning: the cognitive agent makes predictions about the possible evolutions of the entities, and, in the case where a covariation is $foreseen$, the entities are conceived as entering a network. In the case where the entities are only *observed* as covariating, and there is no counterfactual reasoning relating them within a network, the distributive reading raises. As the result of the inferential constraint by which the agent counterfactually relates properties of individuated objects, the whole is nowhere else but in the network of related entities.

[7]This conception goes back to Aristotle; see *Metaphysics*, especially book Z Chs. 10,17; book H Ch.6.

[8]This conception goes back to Plato; see *Theaetetus* 202e-205e, and particularly 203c-205a.

Under this account, the distinction between accidental vs. non-accidental association is expressed in terms of "observation" vs. "prediction" about the existence of a covariation of the properties of the parts. As far as the parts are thought of as covariating, they can be thought of as forming a whole. On its side, the whole is the resulting structure of this covariation.

In section (4) we extend our model to cases of stative eventualities, showing that the notion of dependence and property constraint is strictly correlated to that of acquisition of information. We show that, whenever the application of the constraint on properties does not bring new information, the collective interpretation is suspended.

Our conclusion in a theoretical perspective (section (5)) is that the notion of whole as network, going beyond extensionality, can conciliate, as a middle term, two struggling notions: holism and compositionality.

2 Kinds of wholes

There exist a huge amount of literature about the notions of wholes as sums and of wholes as unities[9].

In this section, we recall the foundations of these two conceptions, consider recent linguistic theories which rely on them, and show, in turn, why none of these conceptions is appropriate to explain CODEP. We conclude this section individuating the specificities of this case, which make it to resist the existing explanations.

Wholes as sums

One way of conceiving wholes is as sums. Theories that subscribe to this conception generally use operations of mereological sum or set union over a domain of eventualities or individuals and recognize the axioms of *closure* (3a) and *uniqueness* (3b).

(3a) Closure: A is closed under the operation $\circ$, i.e. for any a, $b \in A$ there is an element $c \in A$ such that $a \circ b = c$

[9]See, among many others, (Russell, 1903) for the contrasting distinctions between sums and unities, called, respectively, "aggregates" and "unities"; see (Frege, 1884), (Goodman, 1951), (Leśniewski, 1916), (Lewis, 1986) for conception of wholes as sums; see (Nagel, 1952), (Simons, 1987), among many others, for theories of wholes as unities. The notion of unity is strictly related and largely inspired by that of "organic unity" (Husserl, 1901), and shares its essential features with that of "Gestalt" (Wertheimer, 1925).

(3b) Uniqueness: If $a = a'$ and $b = b'$ then $a \circ b = a' \circ b'$

On this view, groups are not considered as being of a different nature from the members that compose them and, very importantly, sum and composition are the very same operation[10].

(4) u is a sum of $x_1, x_2, ...x_n =_{def}$ for all y, y overlaps u if and only if y overlaps one of the xs

(5) $x_1, x_2, ...x_n$ compose $u =_{def}$ u is a sum of $x_1, x_2, ...x_n$

This means that there are no extra relations other than the sum of the parts which compose a whole. It follows that wholes as sums are perfectly coextensive with their parts[11]:

(6) *Coextensive determination.* Wholes are coextensively determined if and only if for all u, for all v, for any x, for any y, if u is a whole which corresponds to the x, v is a whole which corresponds to the y, then u is identical to v only if the xs are coextensive with the ys.

Finally, the notion of sum brings with it the principle of universal existence of sums:

(7) *Universal existence of sums.* Whenever we specify individuals, some individual exists which is a sum of those individuals.

These axioms found Lasersohn's (1995) definition of the *togetherness* effect, which, if appropriate, should properly generate CODEP in all and only the appropriate contexts. This definition is stated, in its original form (Lasersohn 1995, p. 190), as in (8).

Let e, g, P, be event, group and property variables. $\ll x_1, x_2, ...x_n \gg$ denotes the group consisting of $x_1, x_2, ...x_n$.

(8) *First condition for group formation.* $\lambda P, e, g.g \in P(e) \& \forall e' \sqsubseteq e(\exists x(x \in P(e') \Longrightarrow P(e') = P(e)))$

This condition states that a group g is the set of people that satisfies a property in each proper and improper part of the collective event. No

[10](Meirav, 2003, p. 40)
[11](Meirav, 2003, p. 224)

other entity can be added in any subpart of e. So a group g is the minimal set satisfying property P.

A corollary requirement is that the property does not have to be distributed to the members constituting the group (Lasersohn, ibid.).

(9) *Principle of no redistribution.* A group g has a property P *together* in eventuality e iff e has a smaller eventuality e' as a part, such that g has P in e', and e' does not have parts such that the members of g have P in those parts.

Consider (10) and its interpretation (11):

(10) John and Mary are carrying the piano upstairs

(11) $\exists E, \exists e_1 \sqsubseteq E[carry(\{j, m\}, e_1)]$

According to the Davidsonian (Davidson, 1990) view of events endorsed by Lasersohn (Lasersohn, 1995, p. 191), the assertion of the sentence involves demonstrative reference to a particular eventuality (the collective event (E)). This eventuality, in the situation we have described, consists in one sub-event, e_1, in which John and Mary are carrying the piano together.

The eventuality E in (10) is collective because there is a sub-event (e_1) in which the individuals do not satisfy the property separately.

In spite of conforming to the intuition of what a collective action is, this account presents a major hurdle when one tries to extend it to the cases of CODEP.

Representation (12) seems to be the only possible one for (1). However, it cannot differentiate the distributive from CODEP reading.

(12) $\exists E, \exists e_1, e_2, e_3 \sqsubseteq E[walk(\ll \{j\}, \{m\} \gg, e_1), walk(\{j\}, e_2), walk(\{m\}, e_3)]$

In the case of a singular predicate such as *walk* the collective event, if any, can only be represented as $e_{walk} = \ll \{walk_j\}, \{walk_m\} \gg$: *by the nature of the predicate*, the property has to be distributed to the individuals, so in e_{walk} John and Mary act both individually and as a group.

Moreover, this very same symbolization represents *any set* satisfying condition (8). Consider the case where John and Mary are two persons walking *accidentally* side by side, going exactly from point A to point B. This set of people satisfies the definition of group given in (8) because it is the minimal set which satisfies the property of walking in every proper and improper part of the event of going from A to B. It follows that (8) cannot capture the difference between accidental and non-accidental association.

This is due to the principle of universal existence of sums (7) to which classical extensional mereology subscribes. Even in the case of purely accidental association the individuals can be summed up in such a way that there is no criterion to distinguish the distributive/accidental reading from the collective/regular interpretation. This distinction appears fundamental in the case of (1) where the distributive and the collective interpretations can only be distinguished on the basis of the distinction between accidentality vs. regularity. This distinction coincides with that between sum and dependence relation, and thus an appropriate account of the collective interpretation for singular predicates will have to integrate the notion of dependence.

Wholes as unities

An alternative way of conceiving wholes is in terms of unity.

The basic assumption endorsed by this conception is that a whole is a primitive, which has parts, without being dependent on the existence of each of them. The principle of composition to which theories of wholes as unit subscribe is not that of sum, but that of *making up*[12]:

(13) for any xs, for all ys, if the xs make up the ys then each of the xs is a part of y

Very importantly, the notion of *making up* is such that the converse of (13) does not hold: if some xs are part of y they do not necessarily make up y.

Indeed, some basic principles grounding the notion of whole as sums are not obeyed by theories of wholes as unties.

(14) Wholes as unities do not obey the principle of universal existence of sums. Whenever some elements exist, a sum of these elements does not necessarily make up a whole.

(15) Wholes as unities do not obey the principle of uniqueness. This is because some elements can be put together in such a way that more than

[12]According to (Meirav, 2003) the notion of *making up* is to be understood in contrast with that of "coextensiveness". Parts contribute to the existence of the whole, but this is not coextensive with them.

a whole can result.

(16) Wholes as unities do not obey the principle of coextensive determination. Wholes are not identical with the sum of their parts.

From the ontological point of view, (Landman, 1989b) and (Landman, 2000) claim that groups are plural entities seen under a certain *perspective*, that is to say, monadic entities of a different nature from the plural entity which underlies them. Once the existence of a unit has been recovered, the accessibility to each of the members is blocked, i.e. the internal structure of the unit becomes completely opaque.

In Landman's ontology only atoms count as entities. Predicates differ with respect to whether they take group atoms or individual atoms in their denotation. Singular predicates (17) never denote group atoms but only individual atoms. They can be pluralized[13] (the "*" indicates the pluralization of the predicate).

(17) John and Mary walk
John $\sqcup$ Mary $\in$ *WALK
John $\in$ WALK & Mary $\in$ WALK
$\rightarrow \forall a \in John \sqcup Mary\ a \in WALK$

Collective predicates (18) take group atoms and do not distribute the property to the members (the $\uparrow$ indicates that the entities in its scope form an indivisible atom):

(18) John and Mary meet
$\uparrow$(John $\sqcup$ Mary) $\in$ MEET
$\not\rightarrow \forall a \in John \sqcup Mary\ a \in MEET$

Some other predicates are ambiguous (19), and a type shifting operation allows one to switch form the distributive to the collective reading (the σ indicates that the plurality in its scope is maximal):

(19) The boys carry the piano individually $\longrightarrow$ The boys carry the piano together
σ(*BOYS) $\in$ *CARRY $\longrightarrow \uparrow$ (σ(*BOYS) $\in$ CARRY)

On the ontological level, the type shifting operation corresponds to a change in perspective and can be translated by "as a group".

[13]See (Link, 1983).

It is of major importance to state under what criteria one can shift the interpretation from a sum reading to a group reading. Landman (2000) provides the collectivity criterion (20):

(20) **Collectivity criterion.** The predication of a predicate to a plural argument is collective iff the predication is a predication of a thematic basic predicate to that plural argument, i.e. is a predication where the plural argument fills a thematic role of the predicate.

In order to keep the theory coherent, Landman assumes that distributive predication is not thematic. However, in some cases, the property can be distributed down to each singular entity of the group, with the collectivity criterion still satisfied. Consider (21):

(21) The journalists asked the president five questions

Landman (2000, pp. 171-172) uses the notion of collective responsibility or team credit, guaranteeing that, even if each singular journalist asks the president five questions, each question is attributed to the press body to which each journalist belongs. In this case, the existence of a group has to be presupposed.

This account raises a major difficulty when we try to apply it to CODEP interpretation of (1) and (2).

According to the collectivity criterion, there are only two ways to model this interpretation:

1. either one assumes that individuals forming a group must not satisfy the property separately, i.e. singular predication can never be interpreted collectively, as Landman assumes at one point in his argument (Landman, 2000, p. 148), in contrast with the fact that (21) can be interpreted collectively;
2. or one has to retrieve the existence of a group in which the individuals are supposed to be involved from the context or from the lexical information (which is the option finally subscribed by Landman for (21)).

The first statement cannot be accepted if one recognizes that there is a collective interpretation for (1):

(22) John and Mary are walking (as a group)
$\uparrow$(John $\sqcup$ Mary) $\in$ WALK and $\forall a \in John \sqcup Mary\ a \in WALK$

The second statement would force the speaker and the hearer to assume that John and Mary form a couple, for instance. This is, however, not mandatory at all. The group does not necessarily pre-exist the eventuality described in the scene. *It is precisely "in walking" that John and Mary do form a group.*

So we have either to admit that CODEP interpretation is incompatible with singular predicates, or to abandon the collectivity criterion.

We assume that singular predication can give rise to CODEP reading and that in these cases no group pre-exists the scene described by the sentence. Consequently, it cannot be grounded on the collectivity criterion. Instead, we agree, and we develop it in detail, that the notion of group is strictly related to that of "perspective".

Unity by virtue of dependence

Theories of dependence *with unity* are an avatar of theories of wholes as unity *tout court.* It is worth mentioning these theories as far as our purpose is to work out the notion of dependence *without unity.* The basic claim endorsed by theories of dependences with unity is that the whole is a unity if and only if there exist some dependence relations among its parts: the unity exists by virtue of the parts functioning together.

Nevertheless, the ontological claim seems still too compelling, if it is mentioned - as in fact it is - to capture cases of CODEP interpretation. According to Moltmann (1997), the way of reasoning goes as follows: the parts are dependent, then they form a unity, and once the whole as unity has come into existence, the access to the parts is blocked. A so-called integrated-whole, the kind of whole at stake under CODEP interpretation, is such that the parts do not keep an independent ontological existence. This reasoning amounts to stating that a collective sentence necessarily denotes a collective event such that the composing events are no longer accessible. Formally this is given by the following condition (Moltmann, 1997, p. 56), where $<_s$ is a proper part relation in situation s:

(23) *(Strict) Collective interpretation.* For entities e and x, a verb f, and situations s and s', f is interpreted collectively in s with respect to e, x, s and s' iff $[f]^S(e, < x, s' >) = 1$, and there is no e', $e' <_s$, such that for some x', $x' <_s x$ and $[f]^S(e', < x', s' >) = 1$

Likewise the other approaches of the notion of whole as unity, this definition fails to capture the fact that dependent sub-events have to remain both independent and accessible under CODEP: a common walk (1ii) exists nowhere but in the co-ordination of independent and accessible walks.

Neither sums nor unities

Let us sum up. There exist two conceptions of wholes at the light of which one could explain notion of collectivity: wholes as sums, wholes as unities.

We have shown that none of these models captures the features which characterize CODEP and, at this point, one seems to come to a certain impasse.

Let us first recall the two characteristic features of CODEP.

(24) **Elements for CODEP**

1. a coherence relation which differentiates CODEP from pure accidental association or distributive interpretation (e.g. two people walking as a group have coordinated trajectories),
2. an access to the group members which differentiates CODEP from "collective responsibility" interpretation (e.g. a walk independent of the walk of each of the people does not exist).

Theories subscribing to the view of wholes as sums cannot make a distinction between two extensionally identical situations are thus too weak to catch the first of the two features. Theories of wholes as unities are too ontologically compelling to capture the second feature.

It is clear now that we are looking for a notion of whole stronger than sum and weaker than monadicity. We claim that coherence relations are necessary and sufficient. They guarantee that the collectivity reading is possible by virtue of the existence of a *network*. There is, then, a third way of looking at wholes: as networks. Individuals functioning together make up a complex object without this abstract object existing *per se*. This is precisely the case for a collective walk.

3 Wholes as networks

The notion of whole as network is nowadays largely studied in computer science, particularly in theories of distributed systems and communicating processes (see, in particular, (Barwise & Seligman, 1997; Milner 1999; Stirling 2001)) and the model we are about to present is partly inspired by Dretske's theory of information flow (1981). Let us first introduce an informal definition of wholes as networks.

(25) **Whole as Network.** To a person with prior knowledge k, f having property p carries the information that f' has property p', in all possible worlds compatible with k, if the person could legitimately infer that f' has property p' from f having property p. f and f' are seen then as entering a network.

The core of the definition rests in the notion of counterfactuality and property relation. From the point of view of the speaker, two entities can enter a network if, for every possible world, their properties maintain a certain relation. More precisely, two entities are considered to enter a network as long as the speaker, given her previous knowledge, can *foreseen* that their properties will *entail* each other in every possible world. In this way, the entities are seen as mutually dependent via their properties. In the case of a CODEP interpretation for the predicate *walk*, the agent can foreseen that the people will coordinate their trajectories. If this prediction cannot be made, and the association is only observed, the distributive interpretation will be the only available one.

This notion of epistemic dependence has to be distinguished, on the one hand, from that of juxtaposition, and, on the other hand, from that of cause.

Two juxtaposed entities can form a collection, but not a unity nor a coherent whole. Juxtaposition is an extensional relation which links entities that belong to a collection. This relation may rely on the fact that entities share some common properties[14]. Nevertheless, the properties of each entity exist totally independently of the properties of every other element in the same collection.

On the other hand, epistemic dependency is weaker than cause, though sharing very deep resemblances. If, one the one hand, cause can be understood as "bringing into existence", there is another notion of cause in the light of which we can understand dependence: that of *covariation* of properties (Lewis, 1973). In (1) for instance, the walk of one of the two people exists independently of the walk of the other. However, under CODEP interpretation, the properties of each of them constrain the properties of the other: they do influence each other trajectories, for instance.

Crucially, like causality, epistemic dependence relies on *types*. Causality is not random, but can be foreseen by virtue of the types of the events involved. This is also the case for dependency. In a weaker way, though: types are called into play when the cognitive agent epistemically links the occurrences of two events. *If the knowledge that one has about the properties of one event entails the knowledge of the properties of another event, then*

[14]See (Simons, 1997) and the notion of FF-relation.

these two events are epistemically dependent. The informational feature is crucial for dependence: for two people to be seen as walking collectively, the property of the walk of one of them has to provide certain information about the walk of the other.

It is reasonable to ask whether the non-accidental character is provided by the existence of a constraint or by the modal notion of possible world. Our answer is that both of these notions are needed. Given one point in time, it is observationally impossible to make the difference between the cases of accidental and non-accidental association and thus formalize the situation by possibly constraining the descriptions. Under the collective interpretation one foresees that the coordination will be kept, in such a way that the notion of constraint and of maintenance of the constraint go hand in hand[15].

Implementation

In this section we work out the model for the notion of network, providing an event-based account (Parsons, 1990). The model is articulated in two domains: objects and descriptions. Individuals and eventualities are objects (26):

(26) D domain of individuals; E domain of eventualities.

Eventualities are temporal entities of any kind, dynamic or stative.

As far as we are considering the propositional content of a sentence, we need to analyze its constituents and assign to each of them the appropriate task in the construction of the overall scene.

Singular NP denote singular objects, plural and conjoined NPs denote sets of plural entities, without requiring any particular structure on this set.

(27) $\| NP^{plural} \| = \{E \subset D \mid \#E > 1\}$

Let, for a predicate f, be I the set of entities that occupy a certain role (agent, patient, theme, ...) in the eventuality denoted by the predicate.

(28) $I = \{d^R \mid \exists(e)(\| f \| (e) \ \& \ \mathrm{Role}(e) = d))\}$

[15]This is corroborated by the fact that with achievements the collective interpretation is lost by *together* which is, in these cases synonymous of *atthesametime*, and is impossible for *with*, which requires that two entities influence one another. See (Jayez and Mari, 2004)

Following Landman (2000), we assume that when a singular predicate is combined with a plural argument, it is pluralized. So, if the predicate is singular, there will be only one event, if the predicate is plural, there will be as many events as participants *irrespective of whether the interpretation is collective or distributive*. Typically, this is the case for the predicate *walk*.

(29) states that for every individual in the set denoted by the plural argument, there is an event, such that the predicate assigns the truth value 1 to every pair $< e, d >$ (indexed on R), if d occupies a certain role in one of the plural events denoted by the pluralized predicate.

(29) $\forall d^R \in I(\exists e(\| f(e, d^R) \| = 1))$

The second domain in the model is that of descriptions or types.

(30) Θ is the set of types

The introduction of types into the model allows us to integrate the cognitive agent's perspective on entities. The cognitive agent can assign a description to any entity, minimally recognizing its location in space and time. A classification (31) is the object's type assignment.

(31) **Classification**. A classification is a triple ($Objects$, $Types$, $\models$), where $Objects$ is a set of objects, $Types$ a set of categories or types, and $\models$ a relation between $Objects$ and $Types$. If $o \in Objects$ and $\sigma \in Types$, $o \models \sigma$ means that the o is of type σ.

Types can be assigned to either individuals or events. Types assigned to events are called *phases* and they register the content of an event, i.e. its past and future developments[16].

For an event of walking, for instance, the phases register the trajectory of the walk. For each point in time, part of the content of an event is represented by its future developments. Assuming a branching time representation (Penczek, 1995), given a certain point in the trajectory, there exist a particular set of points that can continue the walk under description at $t' \succ t$. This set is Markovianly determined, i.e. it does not depend on the whole history of the events but only on the point in which the system is at time t.

[16]They can be compared to object files for abstract objects (Pylyshyn, 2003), which can be seen as a memory structure or a folder which stores information about a given object.

(32) **State space**. s is a set of classifications for which each token is assigned exactly one type. The state space S is complete if every type is the type of some token.

Note that a state space is a *situation*, i.e. an agent-oriented structured part of the reality. Very importantly, a state space is relative to a time t. If one agrees that the agent assigns a description only to tracked objects (Pylyshyn, 2003), a situation, in this perspective, is not generally a smaller "world" compatible with the conceptual capacities of a cognitive agent (Barwise & Perry, 1983). The agent focalizes her attention on some events in which she is interested, and, by "situation" we precisely mean all and only the events that can be assigned a description. This is acknowledged in our model by the fact that we can only use descriptions for the events mentioned in the sentence. The content of these descriptions is retrieved on the basis of contextual and encyclopedic knowledge.

A space state can evolve. Let (33) the space state which describes the events of walking of John and Mary at t.

(33) $s := \{\ trajectory_\tau \models_s e_j\ ;\ trajectory_{\tau'} \models_s e_m\ \}$

This state space can evolve in different manners such as those given in (34).

(34) Possible evolutions of state space (33)

- $s'_1 := \{\ trajectory_\tau \models_{s'} e_j\ ;\ trajectory_{\tau'} \models_{s'} e_m\ \}$
- $s'_2 := \{\ changetrajectory_\tau \models_{s'} e_j\ ;\ trajectory_{\tau'} \models_{s'} e_m\ \}$
- $s'_3 := \{\ trajectory_\tau \models'_s e_j\ ;\ changetrajectory_{\tau'} \models_{s'} e_m\ \}$
- $s'_4 := \{\ stoptrajectory_\tau \models_{s'} e_j\ ;\ trajectory_{\tau'} \models_{s'} e_m\ \}$
- $s'_5 := \{\ trajectory_\tau \models_{s'} e_j\ ;\ stoptrajectory_{\tau'} \models_{s'} e_m\ \}$

S' is the set of space states into which s can evolve, at time t' immediately following t. [17]

(35) $S' = \{\ s' \mid \forall t, t', S.t \succ t' \rightarrow (s^t \hookrightarrow s'^{t'})$

This is all we need to introduce in relation with particular events and their descriptions. Let us consider now the formalization of the proper

[17] The "immediateness" depends on the granularity one has chosen.

notion of dependence. Its formal counterpart is that of *constraint*.

(36) **Constraint**. A constraint is a closed formula of the general form $Q((\tau \models o) \Longrightarrow \rho)$ where, Q is a series of quantifiers, τ a type, o an object and ρ a well-formed formula.

Types correspond to observations and constraints are entailments among observations: x having a certain property entails that y has a certain property. From speaker's perspective, observing that entity x has a certain property means to infer that another entity in the domain has another property. Constraints express then the fact that, if one observation can be made, another observation can also be made. *This fact amounts to the acquisition of a piece of information.*

At this point we can provide a formal condition for the wholes-as-networks interpretation.

(37) **Whole as network: condition for CODEP**

$$\parallel f^{sing}(NP^{pl}) \parallel^{sit,t}_{coll} = \{e_{i,i\in I} \mid \forall i \in I(\parallel f \parallel^{sit,t} e_i = 1 \ \& \ \forall s'_{s\hookrightarrow s'} (\forall\tau((\tau \models_{s'} e_i) \Rightarrow \forall j_{,j\in I} \ \exists\tau'(\tau' \models_{s'} e_j))))\}$$

When it is applied to a plural NP, a singular predicate f^{sing} is interpreted collectively in situation *sit* at time t if it denotes the set of events indexed on individuals and thematic roles such that:

1. the predicate is true for any event involving an individual with respect to a certain thematic role and,

2. for any possible state space s' accessible from s for every description for the eventuality involving any of the participants, this description entails another description for any other eventuality involving any other participant.

Note that we are not supposing that the collective interpretation calls into play a collective event without accessibility to its subevents. Instead, the collectivity is engendered by a constraint with scope upon the description of a set of events, and it exists nowhere but in the constraint relating the entities via their descriptions.

The instantiation of the definition for the collective vs. distributive reading of (1) will clarify our purpose.

(38) CODEP interpretation for (1)

$\|$ John and Mary are walking along the beach $\|^{sit,t}_{coll}$ $= \{e_{(agent\{j\})}, e_{(agent\{m\})} \mid walk(e_j) = 1 \;\&\; walk(e_m) = 1 \;\&\; \forall s'_{s \hookrightarrow s'}$ $\forall trajectory_\tau((trajectory_\tau \models_{s'} e_j) \iff \exists trajectory_{\tau'}(trajectory_{\tau'} \models_{s'} e_m))\}$

(39) Distributive interpretation for (1)

$\|$ John and Mary are walking along the beach $\|^{sit,t}_{distr}$ $= \{e_{(agent\{j\})}, e_{(agent\{m\})} \mid walk(e_j) = 1 \;\&\; walk(e_m) = 1 \;\&$ $\exists trajectory_\tau \exists s((trajectory_\tau \models_s e_j) \;\&\; \exists trajectory_{\tau'}(trajectory_{\tau'} \models_s e_m))\}$

CODEP interpretation (38) contrasts with the distributive one (39) in two respects:

(i) in (39) there is no constraint;

(ii) in (39) the possible evolutions are not taken into account (the association is accidental and can only be captured step by step).

They resemble each other in that there is no independent collective event for (38). These interpretations run as follows. Consider an S in which John and Mary are walking. In S' at t' one of following configurations can be verified:

1. John keeps on walking/stops and so does Mary. There is a *covariation* (Lewis, 1973), so they can be said to walk collectively in S.

2. John stops (or keeps on walking) and Mary keeps on walking (or stops). There is *no* covariation so the formula is false at S.

When there is no covariation, John and Mary are viewed as walking distributively. When a covariation is *observed* there are two possibilities. On the one hand, John and Mary *can* be *considered* as walking "as a group". The agent will *foresee* that the covariation will be maintained, and thus constrains to one another the descriptions of the two events. On the other hand, if the two walks are only *observed* as evolving in parallel and no prediction is made, the parallelism is considered to be accidental. In other terms, (37) is a **rule** of interpretation. It states that it is necessary that under CODEP interpretation the agent foresee that two events covariate. It does not exclude that a parallelism is observationally verified in the case of an accidental association.

4 Co-localization, states and definitory properties

At this point, we have considered only dynamic eventualities. Even though our model seems to capture the specificities of the cases illustrated by (1), its predictive power can be appreciated when applied to cases of stative eventualities (more commonly, states) and co-localization in particular.

Note that these cases belong to the kind of collective interpretations that we have been considering so far, for "to be localized in some place *l*" is trivially distributive.

It is very often the case that one can link two co-localized entities in a non-accidental manner, as illustrated in (40). Some authors even claim that any time two entities are co-localized they can be considered as associated.[18].

(40) The glasses and the decanters are in the cupboard

Under CODEP interpretation, the positions of the glasses and that of the decanters are seen as related to one another. In wholes-as-networks terms, we would suggest that a cognitive agent coordinates the two sets of entities and recognizes that entities of the same type form a structure or a network when they are in the same location. In inferential terms, this amounts to state that one can retrieve the position of the glasses from that of the decanters and vice versa.

However this is not a general rule of interpretation. One cannot collectively interpret (41):

(41) The forest and the lake are at the top of the mountain

Our model explains this impossibility by the fact that the descriptions of the entities are (epistemically) unrelated: the position of the lake (on the top of a mountain) and that of the forest (on the top of the same mountain) are seen as independent of one another. We have now to state why this is the case.

Let us first emphasize that this is not due to the fact that these are non-movable entities; the collective interpretation can in fact be unavailable in cases where the entities are movable:[19]

[18]Among others, see (Moltmann, 1997)).

[19]Of course, any entity in the world can be destroyed or removed in some way. However, we can clearly make a difference between entities that (can) continuously change their position and those which keep it for a considerable amount of time, generally exceeding a human's life.

(42) John and President Clinton are in New York City at the moment

(42) cannot be interpreted collectively unless one considers that John and President Clinton share a certain activity while in NYC, or that they know each other. If John is in NYC independently of President Clinton, the collective interpretation cannot be enhanced solely by virtue of the fact that they share the same localization.

To understand why the constraint cannot be applied in these cases, one has to consider the nature of the property, and to evaluate whether the application of the constraint brings with it a gain of information. Recall, in fact, that the constraint founding the notion of wholes as networks is epistemic, and amounts to relate the knowledge that the cognitive agent has about one entity, to the knowledge that she has about another entity, via a counterfactual reasoning. This entailment brings the benefit of acquiring a new knowledge about the structure relating the entities and, ultimately, the entities themselves.

In this respect, for (41), it turns out that it would be totally informationless to apply a constraint between the properties of localization of the lake and of the forest. It is in fact useless to epistemically link to one another the positions of the lake and of the forest, while knowing them independently. Once it is possible to know the localization of an entity in a definitory manner, it is totally redundant to epistemically associate it to the localization of another entity.[20] In the light of the fact that individual-level properties (i.e. definitory properties[21]) can never be involved in a whole-as-network interpretation, the reader will easily conclude that this is a general rule in the cognitive grammar.

In the case of (42), on the other hand, the co-localization is considered to be irrelevant. It is informationally irrelevant to know the localization of a President with respect to the localization of a citizen (and vice versa), unless the agent previously knows that they share some activity, or that they have a certain relation.

[20]Note that when the collective interpretation is explicitly instantiated (by using the preposition *with* for instance), the epistemic dimension becomes central. Consider the following discourse:

A: *Of what lake are you talking about?*

B: *Of that with the forest nearby!*

In this case, speaker A is looking for a particular lake. The fact of having a forest nearby is relevant for the individuation.

[21]See (Carlson, 1977). It is not possible to interpret *John and Mary are intelligent* collectively.

For both of these two cases, even though for opposite reasons, it is informationally unworthy applying the constraint, and thus the collective interpretation is not available.

5 Conclusion

In this paper we have considered the collective interpretation of distributive predicates that we have analyzed in the light of the notion of compositionality in a formal ontology framework. In this perspective, the scene denoted by the sentences has been understood as a whole whose parts are represented by the entities involved in the scene and explicitly mentioned in the sentence. More specifically we have focused our attention on conjoined and plural NPs and on their relation with singular (or distributive) predication.

There exist different types of collective interpretations which involve different types of relations between the parts and the whole, and which appeal to different conceptions of the notion of whole. In compositionality terms, this amounts to the standard statement that, given some individuated objects which possibly can be brought together into a whole, there exist different modes of assembling such that the nature of the whole is not only function of the nature of its parts, but also of the particular strategy of composition.

We have considered a set of data, characterized by the fact that every member satisfies the same property. The mode of composition that we have taken into account appeals to two specific factors: (i) there exist some coherence or dependence relations among the members; (ii) these dependence relations do not make up a unity.

Existing theories of part-whole structures cannot explain this particular type of collective interpretation that we have labeled as CODEP. As Meirav (2003) has shown in a very recent study, all the theories of part-whole structures elaborated in the course of the history, can be ranged according to two different conceptions: wholes as sums and wholes as unities. Under the first account there exist no mode of composition other than the juxtaposition of the entities. These can enter a unique class by virtue of their similarity. Theories of wholes as sums are based on the axioms of universal existence of sums stating that, whenever some elements are given, it is always possible to sum them together. When applied to CODEP interpretation of singular predication, these theories fail to capture the essential feature which distinguishes it from the distributive one: the entities entertain a non-accidental relation and are not simply juxtaposed.

Another option is to capture the notion of collectivity by that of whole as unity. A unity is characterized by the fact that the parts of the whole are no longer accessible, or, in other terms, they do not have an independent existence from the whole, and, then, from one another. This ontological claim is too strong for CODEP cases. If we consider two people following together the same trajectory, it is clear that the association exists by virtue of the coordination of their walks, and nowhere else.

Consequently, we have elaborated a different model to explain this type of collective interpretation, that we have labeled "wholes as networks". This model is based on the sole notion of dependence, which has to be understood as an entailment between properties of entities trough possible worlds. The cognitive agent authorizes this entailment whenever she foresees that the entities will covary with respect to some particular properties. This model abstracts from the entities themselves and considers the predictions that the cognitive agent will make about the maintenance of a covariation between their properties trough possible worlds.

The reason to introduce an intensional relation is that the record of mere extensional events is not sufficient to distinguish a pure accidental from the regular association. In this respect, the difference between the distributive and the collective reading is formulated as a difference between mere *observation* and *prediction*.

Crucially, our account is based on the notion of information flow and gain of information. Whenever the agent associates two entities via their properties by a counterfactual reasoning, she is gaining information about one entity from what she knows of the other.

This model seems not only appropriate to capture the specificities of the particular type of collective interpretation in case of dynamic eventualities, but it also provides interesting predictions about the nature of the properties that can be involved in a whole-as-network interpretation. Definitory properties are epistemic-constraint-proof, as far as there would be no extra information added by relating to one another entities that can be known by one of their definitory properties steadily. Triggering data about co-localization in particular can be explained in the light of this statement. Co-localization is not sufficient to enhance the collective interpretation, as often argued. If some entities can be localized in an absolute way, it is informationless to relativize their position to that of another entity. Whenever the wholes-as-networks interpretation rises, the agent has to make sure she can gain some information.

It is highly predictable that this general pattern of reasoning is instantiated in the grammar by specific constructions and lexical items. Let us mention the adverbial *together*, the preposition *with* and the expressions of reciprocity. A detailed study of these constructions is outside the scope of this work, whose aim was restricted to the introduction and the elaboration of a different manner of conceiving wholes, which, leaving extensionality far behind and adding intensionality with the topological notion of state space and epistemic constraint, opens a middle way between the set theoretic notion of sum and holism.